MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

EME2146 – APPLIED THERMODYNAMICS
(ME)

02 MARCH 2019
2.30 p.m. - 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of five pages (including the cover page) with four questions.
2. Answer ALL four questions.
3. Each question carries 25 marks and the distribution of the marks for each question is given in brackets [ ].
4. Write all your answers in the answer booklet provided.
5. Property-tables booklet is provided for your reference.

Question 1

Methanol gas (CH_3OH) is delivered at 25 °C, 100 kPa and at the rate of 160 g/s. It is mixed with 300 % stoichiometric amount of reactant at 330 K and 100 kPa. The reactant composition ratio of nitrogen to oxygen is 4 (by mole). The mixture is combusted completely. The product gases reach 1000 K at the end of the combustion process. Assume ideal gas for the mixtures of products and reactants where the universal gas constant, $R = 8.314$ J/mol·K.

Substance	N_2	O_2	CO_2	H_2O	CH_3OH
Molecular weight (kg/kmol)	28	32	44	18	32

a. Write the stoichiometric combustion equation.

[3 marks]

b. Write the combustion equation with 300% stoichiometric amount of reactant.

[3 marks]

c. Calculate the reactant to fuel ratio.

[3 marks]

d. Find the enthalpy of formation for CH_3OH, CO_2, and H_2O at 298 K and 100 kPa from the property table.

[3 marks]

e. Determine the rate of heat transfer from the combustion in kW.

[8 marks]

f. If the reactant contains a certain amount of water vapor in the mixture, rewrite the combustion equation of part (b). The mole fraction of water vapor is 0.06.

[2 marks]

g. Determine the rate of heat transfer from the combustion in kW for the case in part (f).

[3 marks]

Continued...

Question 2

A steam power plant operates in the Rankine cycle. Water enters the reversible pump as saturated liquid at 10 kPa (State 1). It is compressed and delivered to the boiler (State 2) at a constant flow rate. Water is running through the boiler where the pressure is maintained at 3 MPa. Heat is transferred and water exits the boiler as superheated vapor (State 3). The superheated water vapor flows through an isentropic turbine (State 4). The water is then cooled by a condenser before it is supplied to the water pump (State 1) for the next cycle. Water exits the turbine as saturated vapor and the net power output from the power plant is 2 MW.

a. Sketch and label the $T - s$ diagram of the cycle.

[2 marks]

b. Sketch and label the $p - v$ diagram of the cycle.

[2 marks]

c. Find enthalpies at state 1, 2, 3 and 4 in kJ/kg.

[5 marks]

d. Calculate the mass flow rate of the water in kg/s.

[3 marks]

e. Calculate the rate of heat transfer at the boiler in kW.

[3 marks]

f. Calculate the rate of heat transfer at the condenser in kW.

[3 marks]

g. Determine the thermal efficiency of the cycle.

[2 marks]

h. If the maximum temperature of the cycle is raised to 1000 °C, what is the thermal efficiency of the cycle?

[5 marks]

Continued...

Question 3

a. A rigid tank, of 1.5 m^3 volume, contains an ideal-gas mixture at a total pressure of 600 kPa. The mixture consists of 8.0 kg of gas A and 4.0 kg of gas B, the molecular weights of which are $M_A = 32.0$ kg/kmole and $M_B = 28.0$ kg/kmole, respectively.

i. Determine the mass fraction of A and B.

[3 marks]

ii. Determine the mole fraction of A and B.

[5 marks]

iii. Determine the partial pressures p_A and p_B.

[2 marks]

iv. Determine the molecular weight of the mixture.

[2 marks]

v. Determine the temperature of the mixture. The universal gas constant $\bar{R}$ has the value of 8.314 kJ/kmole·K.

[2 marks]

b. A mixture of dry air and water vapor, of 300 °C temperature and 500 kPa total pressure, has a dew-point temperature of 50 °C. It enters a thermally insulated turbine and, in the absence of vapor condensation, expands to the exit temperature of 25 °C. Determine the (total) pressure of the mixture at the turbine exit if it leaves the turbine as a saturated mixture.

[11 marks]

Continued...

Question 4

A cylinder fitted with a movable frictionless piston contains an ideal gas, as illustrated in Figure Q4. The piston, through the shaft, is connected to a non-linear spring (not shown in the Figure) so that the pressure and specific volume of the gas are related by the formula

$$\frac{p}{p_0} = 1 + \left(\frac{v}{v_0} - 1\right)^2$$

The initial specific volume, pressure, and temperature of the gas are, respectively, v_0, p_0, and T_0. An amount of heat per unit mass of the gas, q, is then transferred from a reservoir, of temperature $T_H = 4.5\ T_0$, to the gas so that it expands to its final specific volume $v_1 = 2v_0$. During the expansion process, 10% of q is lost by the gas to the ambient, the temperature of which is equal to T_0. The constant-volume specific heat of the gas is given by $c_v = 2.5\ R$, where R is the gas constant.

a. Determine the initial temperature T_0 and final temperature T_1 of the gas. Express your answer in terms of p_0, v_0, and the gas constant R.

[3 marks]

b. Determine the work done by the gas. Express your answer in terms of p_0 and v_0.

[4 marks]

c. Determine the heat transfer q from the heat reservoir to the gas. Express your answer in terms of p_0 and v_0.

[8 marks]

d. Determine the reversible work which could be delivered and the second-law efficiency, given the initial and final states of the gas as well as the heat transfer q. Express your answer in terms of p_0, v_0, and the gas constant R.

[10 marks]

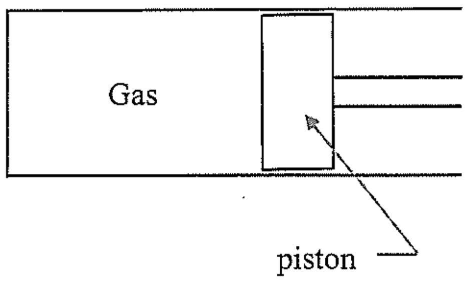

Figure Q4.

End of Paper